

Search for a diffuse flux of cosmic neutrinos with ANTARES



ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS



TAUP 2013
Asilomar, California
10th September 2013
Jutta Schnabel

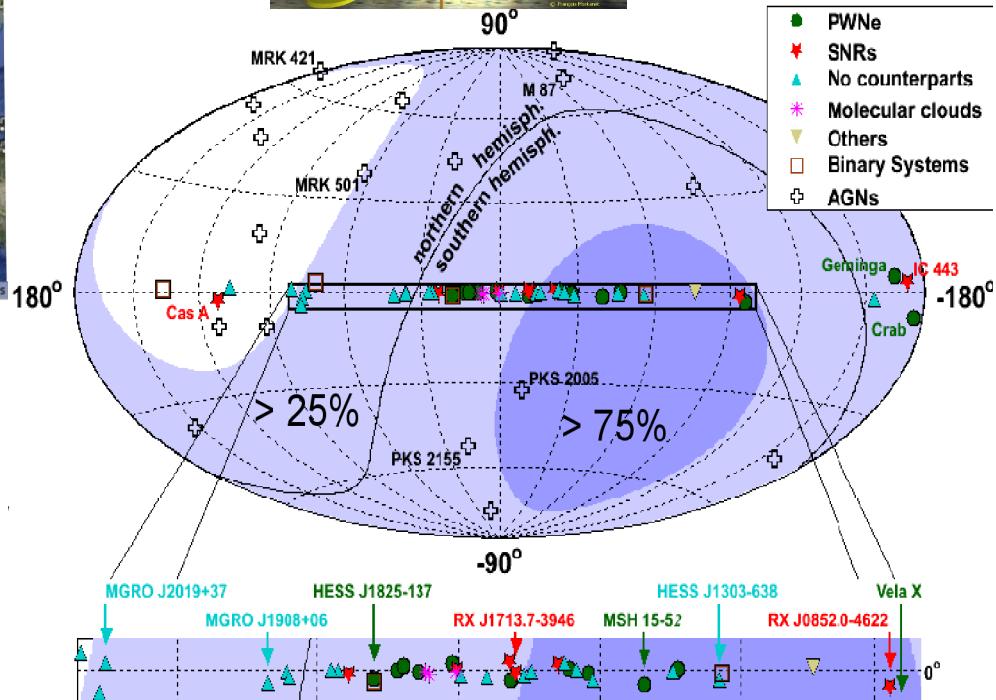
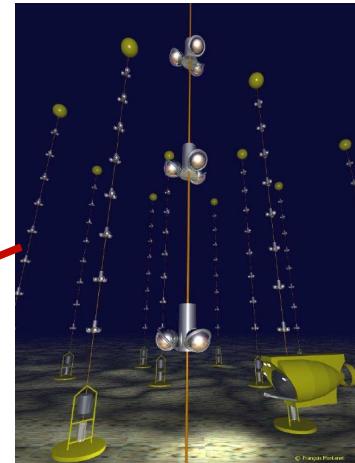
ANTARES



ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS



Cherenkov detector in the Mediterranean Sea by a European collaboration of 31 institutes from 8 countries



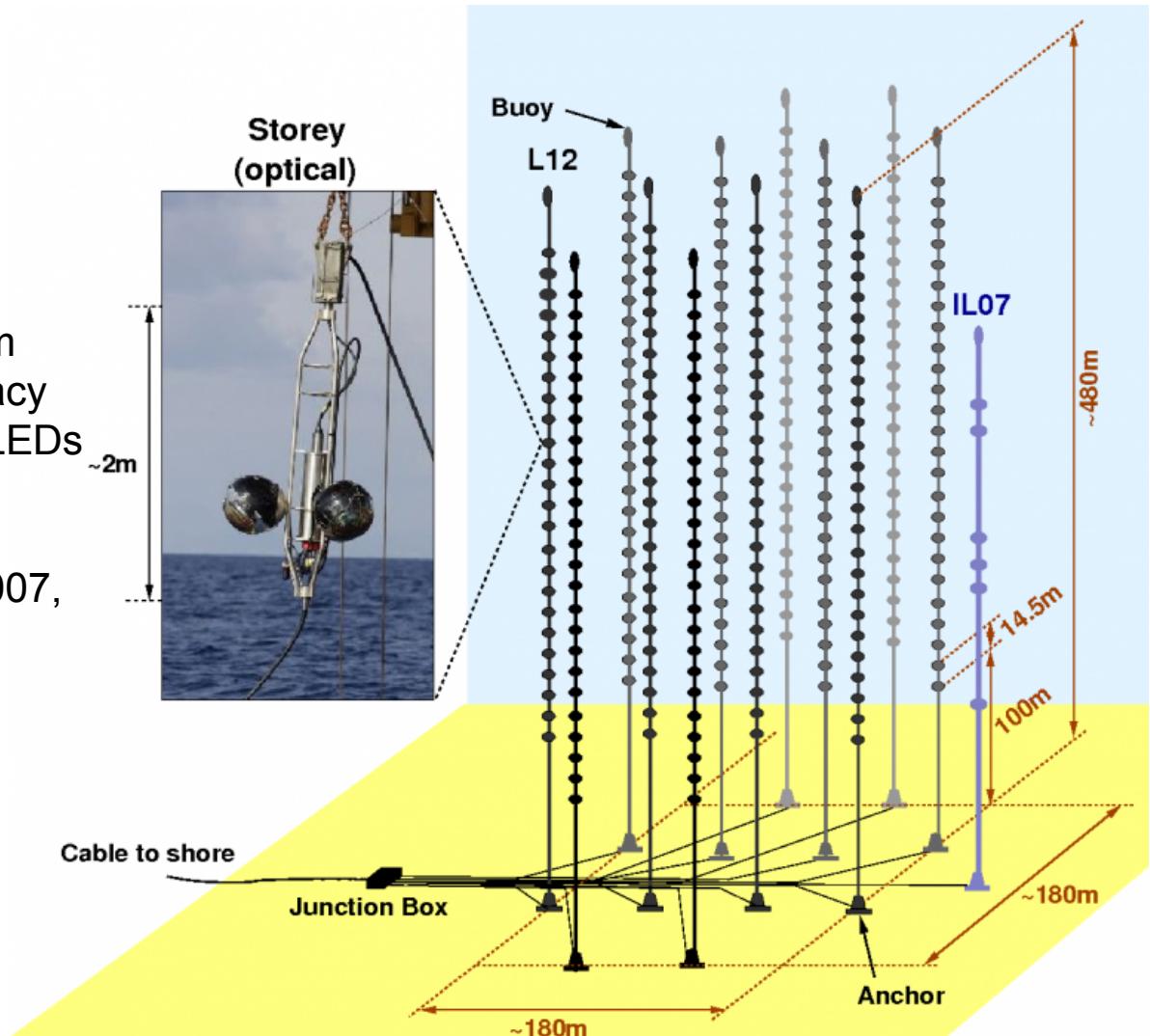
The experiment



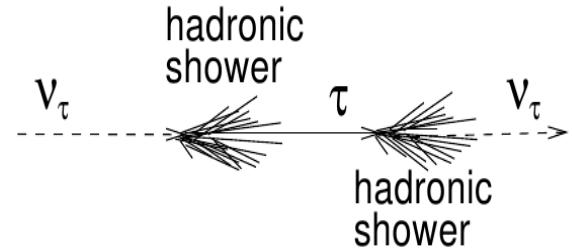
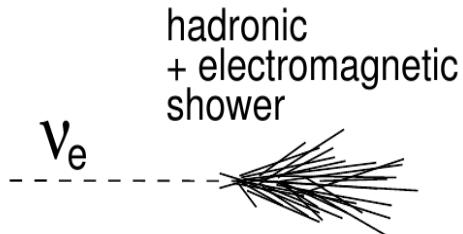
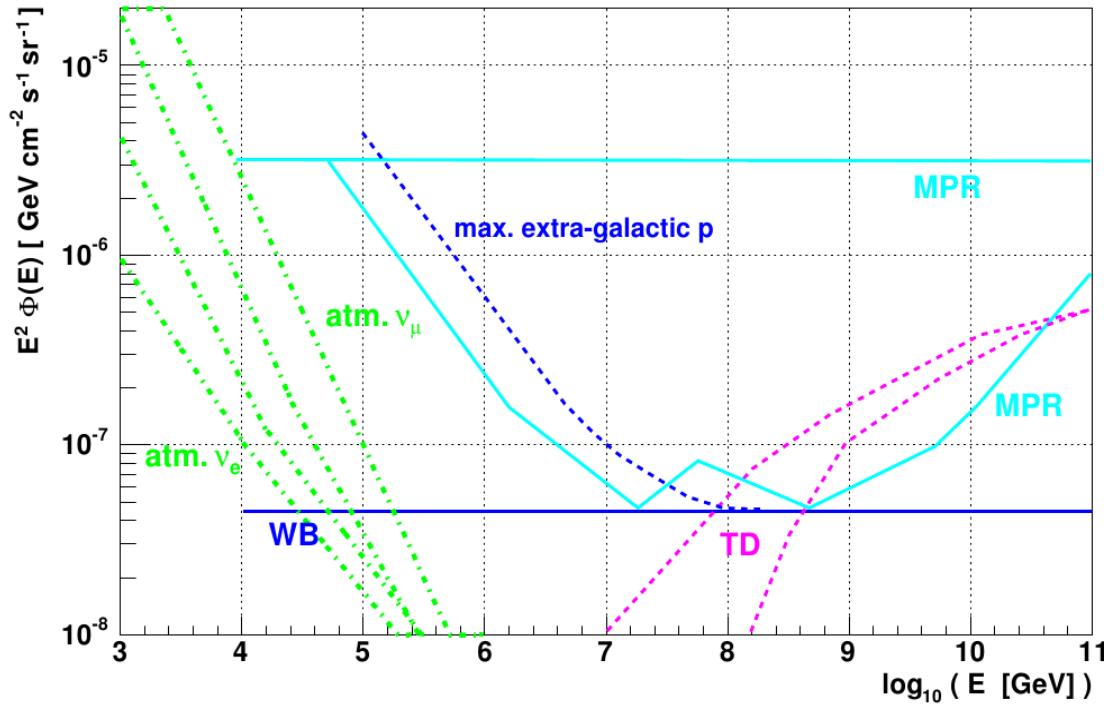
885 Optical Modules
with one 10 inch PMT each,
on 12 detection lines
floating at 2500m depth

- Acoustic positioning system
→ 10cm positioning accuracy
- calibration of PMTs using LEDs
→ 2ns timing accuracy

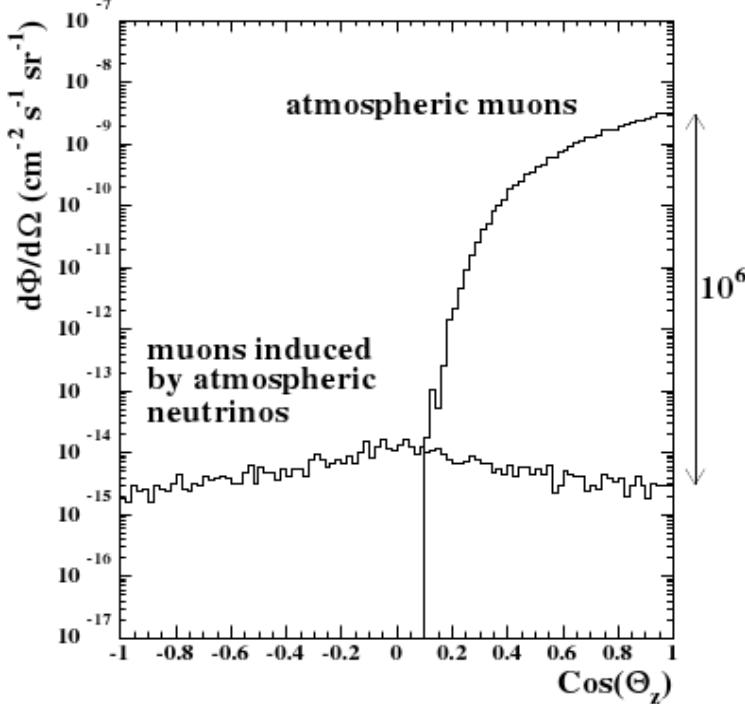
Taking multiline data since 2007,
fully deployed since 2008.



Diffuse neutrino flux detection



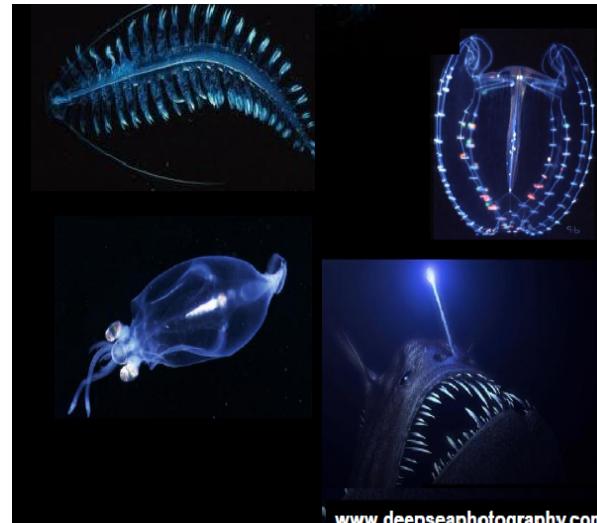
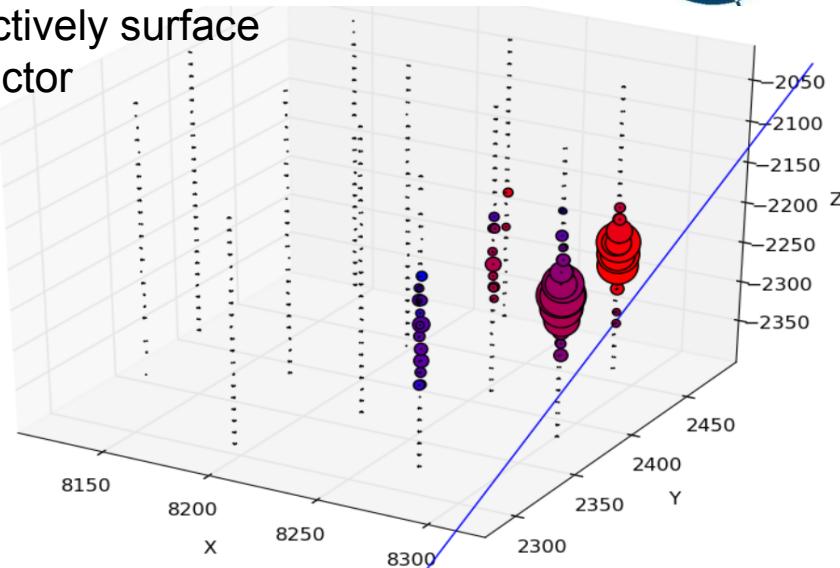
Challenges for diffuse flux analyses



atmospheric muon background
at the site

**Need effective hit selection
strategies and suppression of the
atmospheric muon background!**

effectively surface
detector



bioluminescence

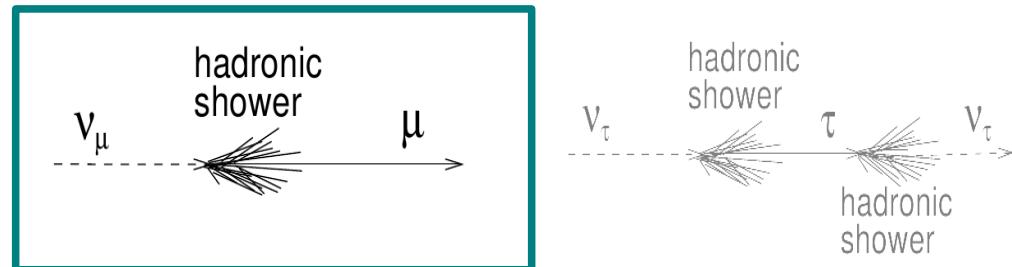
Overview over recent analyses



ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS

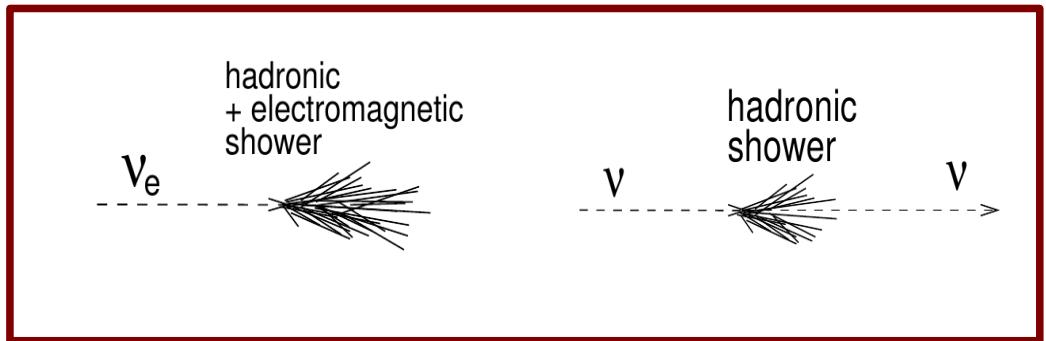
CC-muon analyses

- 2008-2009 data
Phys. Letter B 696 (2011)
16-22 [arXiv:1011.3772]
- 2008-2011 data
2 complementary analyses



Shower analyses

2008-2011 data
2 analyses with different
reconstruction methods

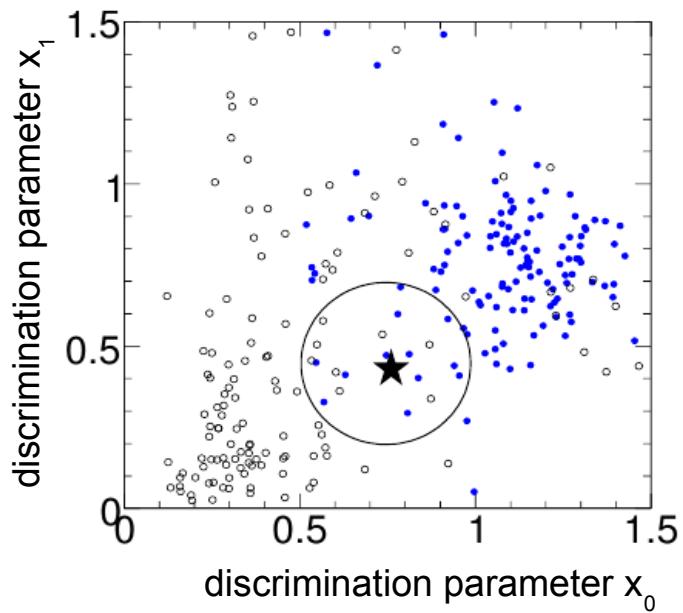
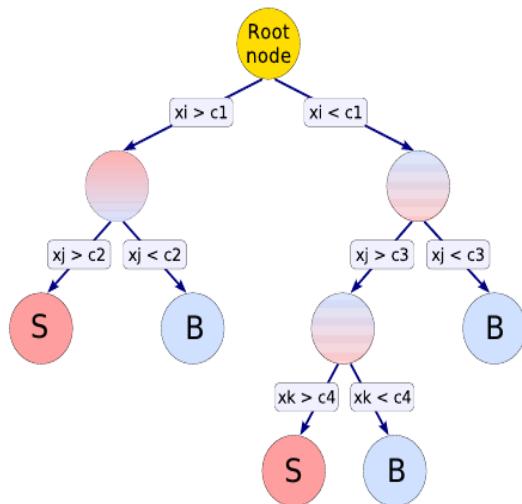
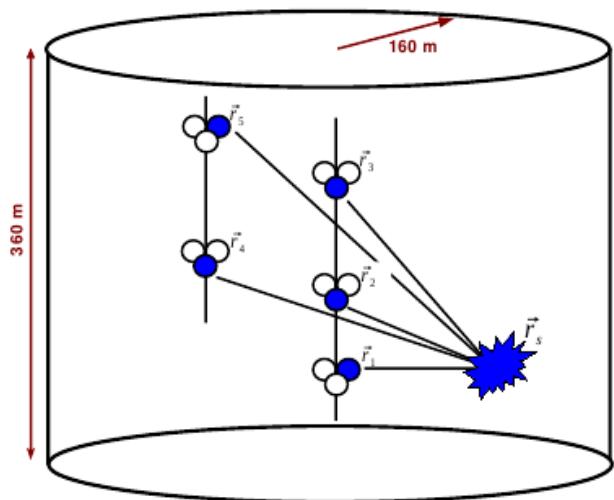


UHE analysis

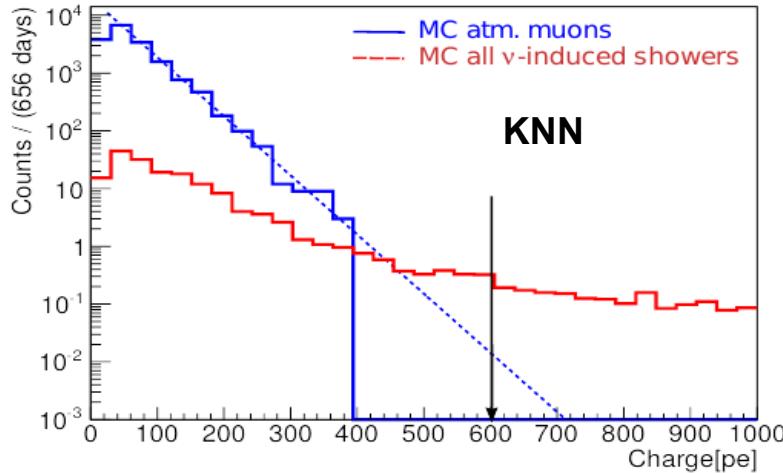
(no official results yet)

Shower analysis I

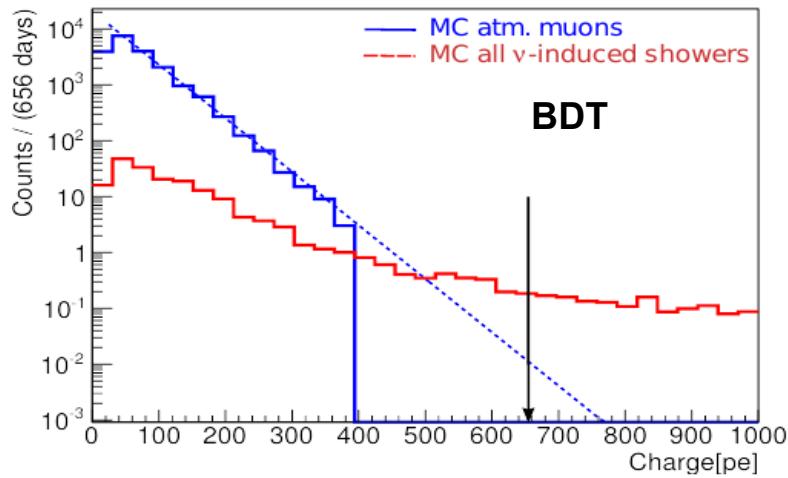
- 4-step vertex reconstruction, direction reconstruction & energy estimate
- atmospheric muon reduction through event selectors
(Boosted Decision Tree, KNN)



Shower analysis I



MVA method	cut-doublet	N_{ν_s}	N_μ	N_μ^{exp} (after exponential fit)	purity
KNN	(600 p.e., 0.27)	3.9	0	0.02	99.5%
BDT	(658 p.e., -0.09)	3.5	0	0.01	99.7%



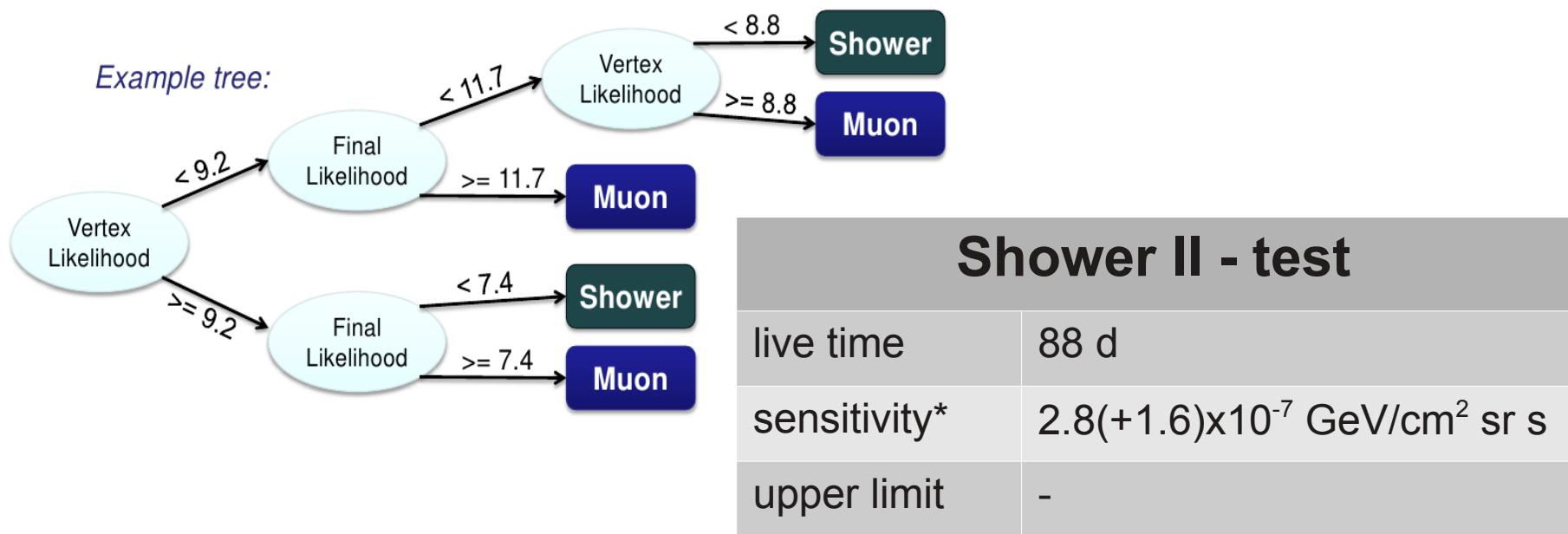
Shower I (not unblinded)

live time	656 d
sensitivity*	$2 \times 10^{-7} \text{ GeV/cm}^2 \text{ sr s}$
upper limit	-

* per flavor

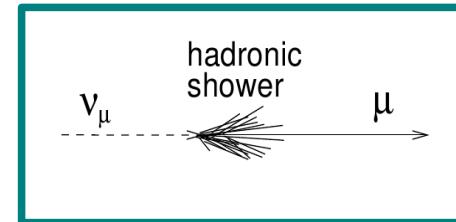
Shower analysis II

- Independent hit selection, vertex and energy/direction reconstruction
- Using Random Decision Forest for event selection



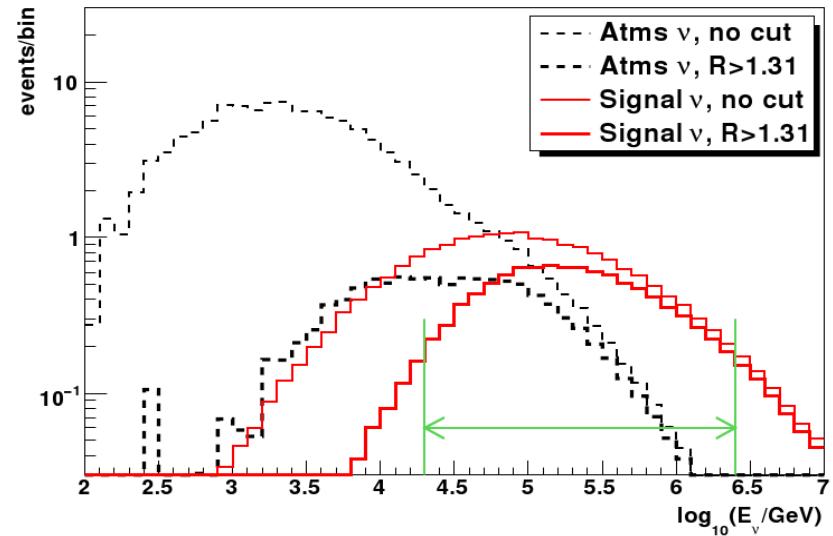
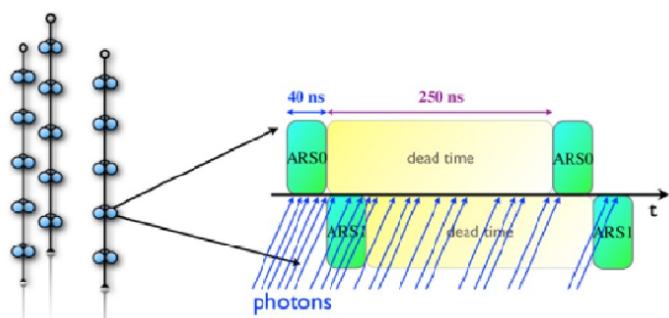
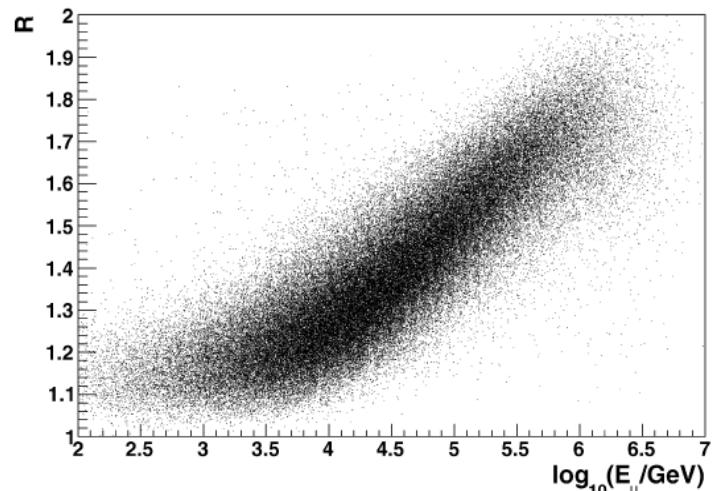
* per flavor

First CC-muon analysis



Phys. Letter B 696 (2011) 16-22 [arXiv:1011.3772]

- Event selection using track parameters
- Energy reco using the R-parameter



μ – CC, published

live time	334 d
sensitivity	7.0×10^{-8} GeV/cm ² sr s
upper limit	5.6×10^{-8} GeV/cm ² sr s
validity range	20 TeV-2.5 PeV

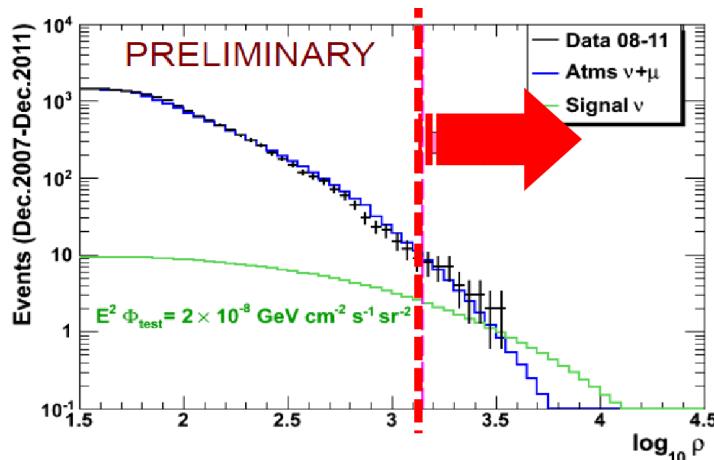
After four years of data



- New energy reconstruction methods developed
- Event selectors introduced

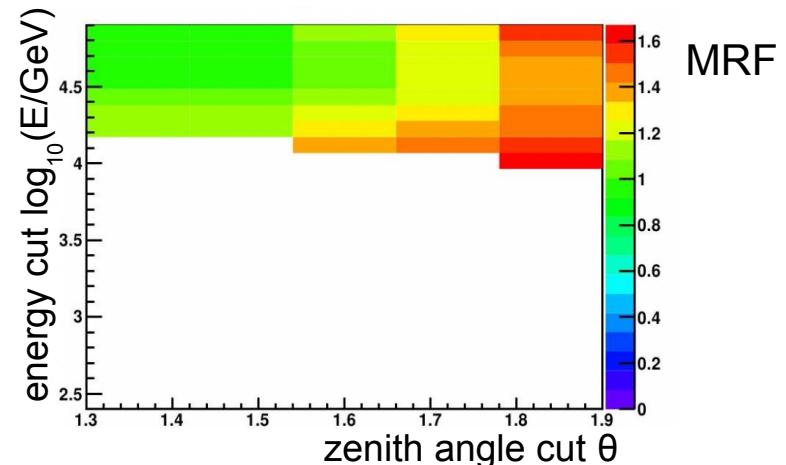
“heuristic” approach

1. Minimize contribution of atmospheric muon background
2. Maximize sensitivity through energy estimate

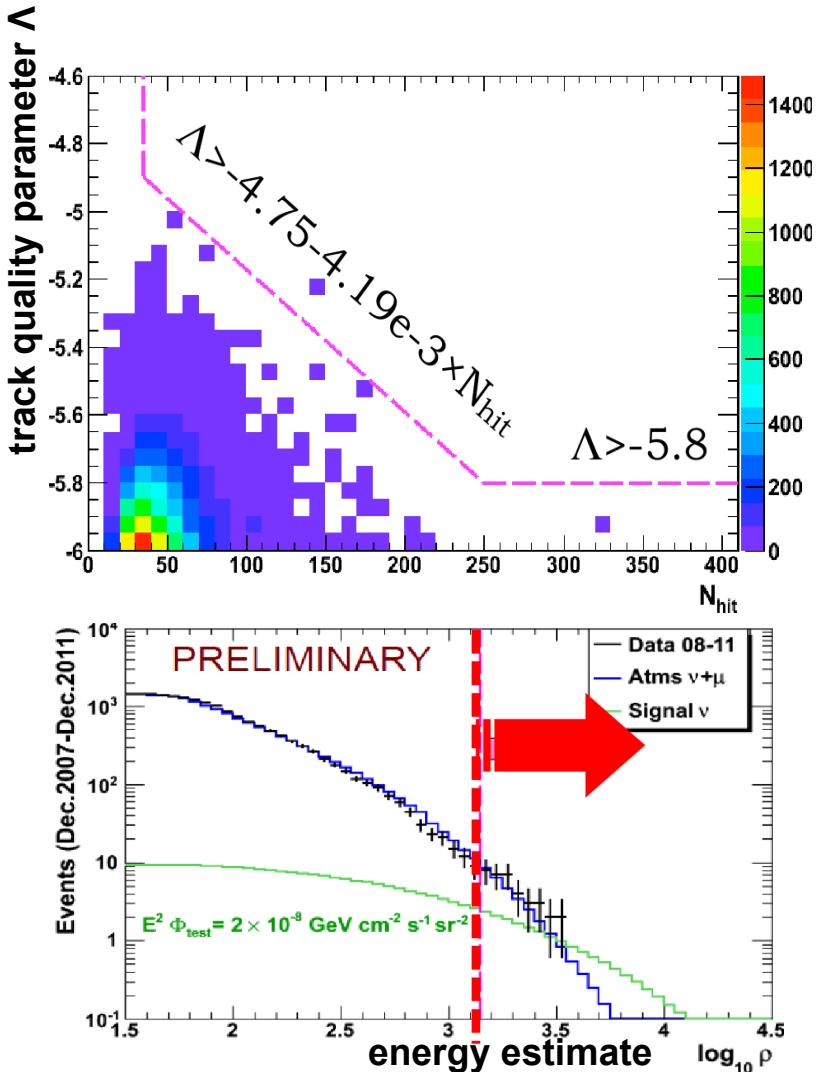


“multivariate” approach

Scan available parameter space for maximum sensitivity regardless of atmospheric muon contribution



“Heuristic” approach

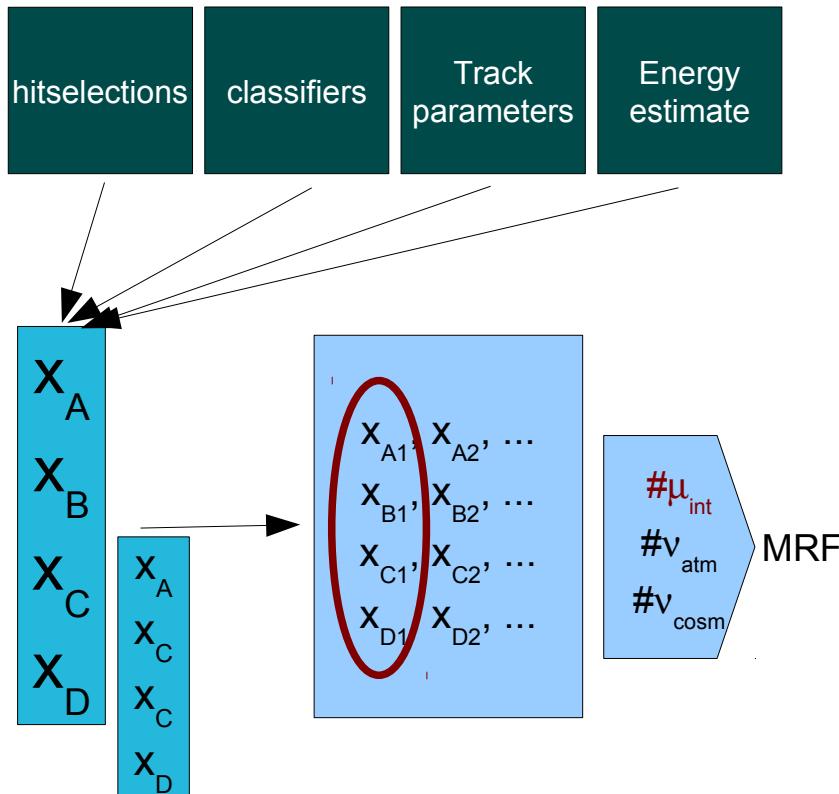


- Using track reconstruction parameters for suppression of atmospheric muon background
- Replacing energy estimate by dE/dx algorithm

$\mu - \text{CC I}$

live time	885 d
sensitivity	$4.7 \times 10^{-8} \text{ GeV/cm}^2 \text{ sr s}$
upper limit	$4.8 \times 10^{-8} \text{ GeV/cm}^2 \text{ sr s}$
validity range	45 TeV-10 PeV
bkg. expectation	8.4
events in data	8

“Multivariate” approach



1) select set
of cut
variables

2) cut MC set on
all combinations
of defined cut
values

- Strong use of track quality parameters
- energy reconstruction through ANN

$\mu - CC\ II$	
live time	903 d
sensitivity	$4.2 \times 10^{-8} \text{ GeV/cm}^2 \text{ sr s}$
upper limit	$7 \times 10^{-8} \text{ GeV/cm}^2 \text{ sr s}$
validity range	65 TeV-10 PeV
bkg. expectation	8.3
events in data	12

Summary



- Diffuse flux analyses including NC and CC have been performed/are performed on ANTARES data from 2008-2011
- The sensitivity of ANTARES for this period for a CC-muon flux reaches $\Phi_{\bar{\nu}\mu+\nu\mu} E^2 = 4.7 \times 10^{-8} \text{ GeV/cm}^2 \text{ sr s}$
- No signal is found, and upper limits of the various CC-muon analyses range between $\Phi_{\bar{\nu}\mu+\nu\mu} E^2 = 4.8 - 7 \times 10^{-8} \text{ GeV/cm}^2 \text{ sr s}$
- Inclusion of more recent data and combination of searches of different interaction channels under way.

The background is a deep blue underwater environment. On the left, a white submersible with the word "nautilus" on its side is illuminated from within, casting a bright beam of light downwards. In the center, numerous green cylindrical bubbles rise through the water, some accompanied by smaller black spheres. A school of small, silvery fish swims in the upper left. The bottom right corner features a large, textured blue sphere, possibly a rock or coral formation.

Keep ANTARES on the sonar
& thank you for your attention